NATIONAL ACADEMY OF SCIENCES

Number 51 • September 1961

IGY BULLETIN

A monthly survey of plans, activities and findings in geophysics—with emphasis on United States contributions to the International Geophysical Year, International Geophysical Cooperation–1959, and similar international endeavors including the World Magnetic Survey, the Year of the Quiet Sun, the Indian Ocean Expedition, the Antarctic research program, and space exploration and research. Preparation and publication of the Bulletin *is supported by the National Science Foundation.*

Survey of the Earth's Magnetic Field

The World Magnetic Survey

The IGY program in geomagnetism included a proposal for a world-wide survey of the earth's magnetic field. Inasmuch as the IGY itself was timed to coincide with the period of maximum solar activity, when magnetic storms and other disturbances of the geomagnetic field are at their peak, major phases of the magnetic survey were deferred until a time of solar quiet so that the field could be surveyed with a minimum of interference from solar-induced disturbances. Present planning calls for the World Magnetic Survey (WMS), which uses data gathered since 1955, to heighten its efforts during the International Year of the Quiet Sun (IQSY), April 1964–December 1965, when, it is predicted, the minimum of solar activity will occur; survey activity now underway will also contribute to the WMS.

The Geomagnetic Field

At the earth's surface and in its atmosphere the geomagnetic field closely resembles that of a short bar magnet imagined to be located at the earth's center with its north-seeking pole directed towards Antarctica, or of a uniformly magnetized sphere (see Fig. 1) the axis of which is inclined about 11.5° to the earth's axis of rotation. The points where the axis of the sphere intersect the earth's surface are the geomagnetic poles; the geomagnetic pole in the Northern Hemisphere is located near Thule, Greenland.

The unit of magnetic field intensity commonly used is the *oersted,* which is defined in terms of the unit magnetic pole. In the centimeter-gram-second system of units, two unit magnetic poles exert a force of one dyne (one gram-centimeter per second per second) on each other when at a separation of one centimeter. A field of one oersted

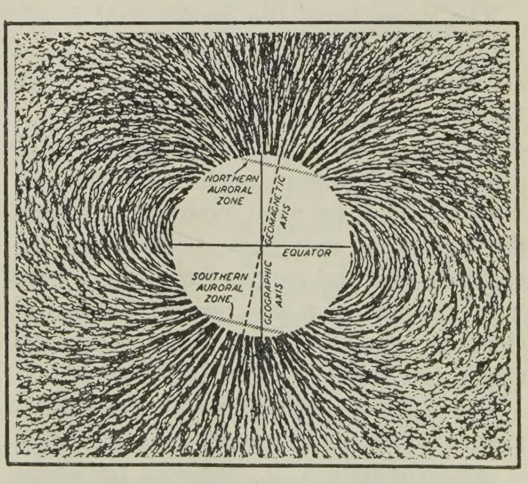


Fig. 1. *Schematic Representation of the Earth's Magnetic Field. Field resembles that of a short bar magnet near Earth's center, with north-seeking pole directed towards Antarctica and with axis of corresponding uniformly magnetized sphere inclined about 11.5° to Earth's rotation axis.*

exerts a force of one dyne on a unit magnetic pole. The magnetic field intensity is sometimes given in *gauss;* the gauss was formerly the unit of intensity but was redefined in 1932 as the unit of magnetic induction such that an induction field of one gauss produces an electromotive force of one abvolt, or 10^{-8} volts, in a straight wire one centimeter in length that moves perpendicularly through the induction field at a velocity of one centimeter per second. The gauss and oersted are essentially equivalent measures of field intensity, differing only in their application to magnetic fields arising from different causes.

The field intensity between the pole pieces of a small toy horseshoe magnet may be hundreds of oersteds; the fields of industrial magnets or the magnets used in magnetrons may be some thousands of oersteds; the fields of magnets in cyclotrons and other large high-energy accelerators may be approximately ten thousand oersteds; the field in the gap of a large low-frequency high-fidelity loudspeaker may approach twenty-thousand oersteds; and super-high magnetic fields of nearly a million oersteds have been produced in laboratory experiments.

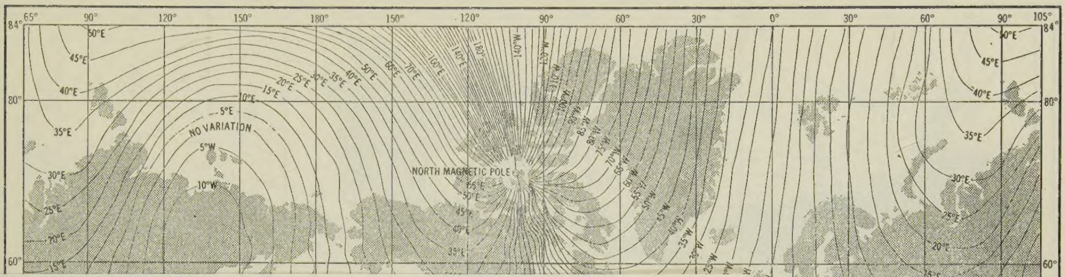
The intensity of the earth's field is approximately one-half oersted, by most standards of common experience a weak field. Yet, the geomagnetic field occupies a very large volume and, since the energy of a magnetic field is proportional to the volume, the field is a most important factor in the terrestrial environment, screening the earth's equatorial regions from cosmic rays with energies of a few tens of billions of electron volts and trapping charged particles in the Van Allen Radiation Belts.

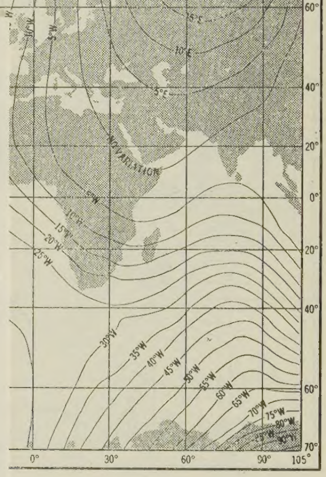
The magnetic energy in a shell one kilometer thick around the earth near its surface is approximately 5×10^{21} ergs (or about 10^8 kilowatt-hours); since the geomagnetic field is still distinguishable from the background field of interplanetary space at distances of 10–13 earth radii, the total energy of the geomagnetic field is clearly quite high. On an even larger scale, it is estimated that the magnetic fields of the galaxies, with strengths of the order of 10^{-5} to 10^{-6} oersted, contain energies 100 to 1000 times the total energy emitted by stars. Small changes in the earth's field are usually measured in units (called *gammas*) of 10^{-5} oersted.

The actual geomagnetic field is somewhat irregular as a result of inhomogeneities in the earth's crust and, possibly, in the upper mantle as well. These inhomogeneities may be, for example, concentrations of rock rich in iron. Most rocks, however, are magnetic to some degree, and large-scale features of the earth's crust commonly have magnetic anomalies, or departures from uniformity in the field associated with them.

In addition, the seat of the magnetic field in the interior of the earth appears to be non-uniform and changing slowly with time. Whatever the origin of the field is—and there is only imperfect theory today concerning this problem—it seems necessary to conclude that there is a relation between the causal mechanism and the earth's axis of rotation. This coupling, however, permits the magnetic axis to be tilted with respect to the rotational axis, as noted earlier, and to be displaced. The displacement was deduced from harmonic analysis and later confirmed by careful longitude and latitude surveys of cosmic-ray intensity in the equatorial region; it is estimated that the magnetic axis is displaced at the earth's center by some 200 km (125 mi) in the direction away from the South Atlantic Ocean. The direction of the displacement was one of the factors in selecting the South Atlantic as the site for the Argus experiment (see *Bulletin No. 27*).

From observations beginning during the nineteenth century (after K. F. Gauss had invented the first practical magnetometer and organized a cooperative network of magnetic observatories) it has been learned that the strength of the geomagnetic field has been decreasing—about 6% in the past 100 years. It has also been learned that the patterns of change in the earth's field





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points of equal variation
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which may be described by components resolved along any convenient reference frame. For mapping purposes, the geomagnetic field is commonly described in terms of:

F—the strength of the field, or the absolute magnitude of the total-field vector, $\bar{F}$

H—the horizontal intensity, or the mag-

ıny point, of the vector $\bar{H}$
ɔnent of $\bar{F}$ projected on a
ənt to the earth's surface
nt)

l intensity, or the magni-
ıy point, of the vector $\bar{Z}$
nent of $\bar{F}$ projected on the
that point)

tion, or the angle that $\bar{H}$
the meridian of longitude
ıy point (sometimes also
variation of the compass)

tion, or the angle that $\bar{F}$
the vertical at any point.

For the actual geomagnetic field, the magnetic poles are defined as those places where the inclination is 90°. The magnetic equator, conversely, is defined as the locus of points where the inclination is zero. Magnetic anomalies may be large enough at some locations to mask the character of the general geomagnetic field, and for mapping the

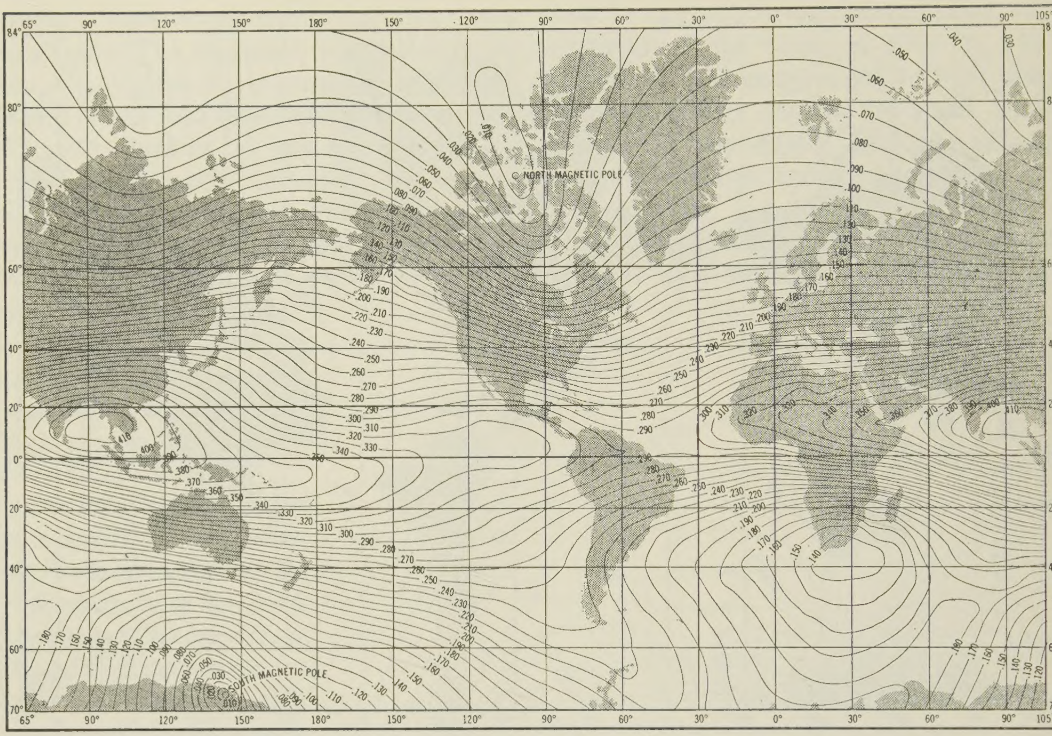

Fig. 3. *World Map of Horizontal Intensity, H, of Geomagnetic Field, 1955. Lines connect points of equal value (expressed in oersted) of H. Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

field on a large scale, for example the entire earth, the local anomalies and small-scale distortions are averaged out.

Types of Geomagnetic-Field Maps: Figures 2, 3, and 4 show the 1955 maps of D, H, and Z, compiled by the US Coast and Geodetic Survey with the cooperation of the US Navy Hydrographic Office, the United States institutions responsible for preparing such information for national use. (Agencies in other countries also prepare maps of the geomagnetic field on a regional or a global basis for their own needs.) Maps of declination, D, of the field are usually prepared every five years in the US, and maps of H, Z, F, and I are recompiled every 10 years.

Between the years when new maps are issued, the work of measuring absolute values of the field elements continues at the network of permanent observatories throughout the world. In addition, temporary locations are occupied with portable equipment so as to provide more complete coverage.

The observatory network also provides a means for keeping track of the slow changes in the field, or the secular variation. It is necessary to know how the field is changing in order to correct all readings to the epoch of the next chart. Thus, after the 1955 charts (Figs. 2, 3, and 4) were completed, measurements in the period 1955–1960 were corrected to show the value of the various field elements as of 1960, the epoch of the next chart. Similarly, although special emphasis will be placed on the World Magnetic Survey during the period 1964–1965, measurements made for a decade or more prior to 1965 will be used to compile the WMS charts, with appropriate corrections for the secular change. Figure 5 shows the annual change in Z; similar world maps are prepared to show the secular variation in D and the other field elements.

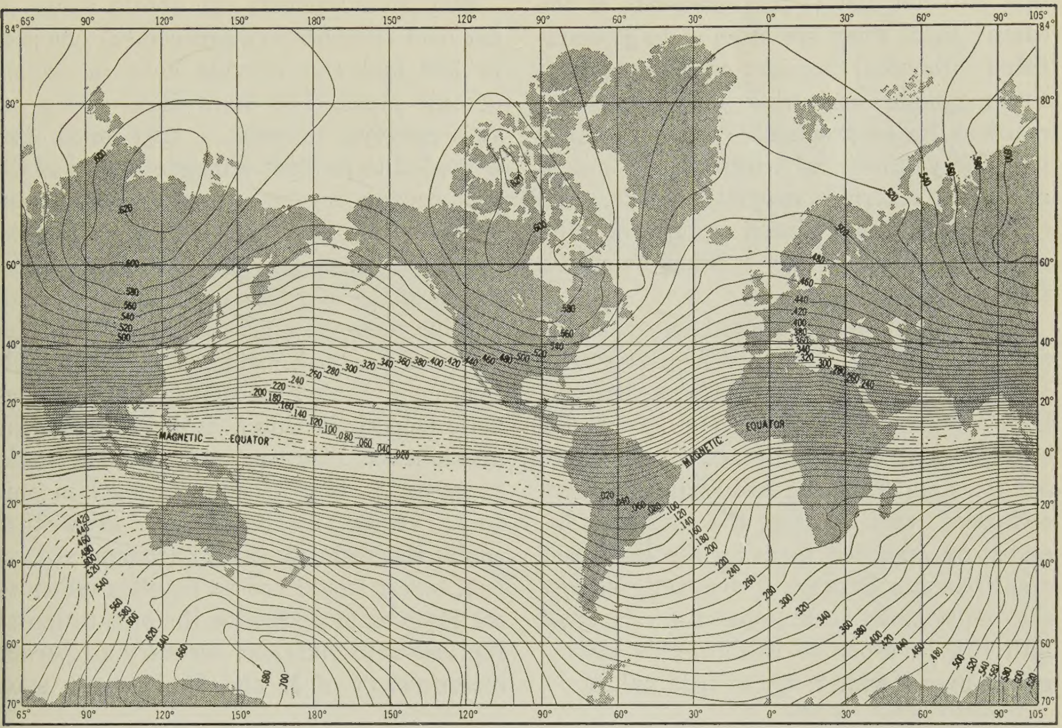

Fig. 4. *World Map of Vertical Intensity, Z, of Geomagnetic Field, 1955. Lines connect points of equal value (expressed in oersted) of Z. Courtesy of* Encyclopaedia Britannica. *(Map based on US Navy Hydrographic Office chart.)*

Methods of Mapping the Geomagnetic Field

Measurements on Land: As mentioned above, the network of permanent observatories provides a base for survey of the geomagnetic field over land areas, and temporary locations help fill in the coverage. Series of measurements are made over a period of at least several days in order to eliminate the diurnal variation, which arises from daily exposure of the upper atmosphere to heating and ionization by solar radiation and from wind systems generated under the influence of the solar tidal force.

For land stations, the terrestrial coordinate reference frame—north-south, east-west, vertical—can be determined with high accuracy through astronomical methods. The values of the field strength can be determined to a precision of one gamma and the declination and inclination to 0.2 minutes of arc.

Measurements at Sea: Since the surface of the planet is approximately three-fourths water, the magnetic field must be measured at sea as well as on land in order to provide sufficient coverage for accurate mapping. To help fill this gap, specially designed magnetometers were used aboard the non-magnetic ship *Carnegie*, operated by the Carnegie Institution of Washington, in the period 1909 to 1929, until, in 1929, the wooden vessel was destroyed by fire. Since then, a few other cruises by non-magnetic ships have been made, but not until recently has another such vessel been generally available for magnetic observations at sea. This vessel is the USSR non-magnetic ship *Zarya*, which was fitted out during the IGY and has been in steady use since then compiling new magnetic information in oceanic areas.

Non-magnetic ships are constructed of materials such as wood, brass, and bronze

that will not distort measurements of the earth's field. They are often sailing vessels fitted with small auxiliary engines and with the magnetic measuring instruments located as far as practicable from the ship's machinery. Electrical wiring is laid out to minimize external magnetic fields, and small magnets are placed around the ship, if needed, to offset any residual magnetic fields.

The magnetometers aboard non-magnetic ships are regularly checked against standard instruments at land stations, particularly at island locations. The *Zarya,* for example, put in at San Juan, Puerto Rico, in December 1958, and its instruments were compared with those at the magnetic observatory operated there by the US Coast and Geodetic Survey. A magnetic survey ship must make such stops at a variety of latitudes in order to calibrate its instruments over a wide range of field values.

Ship measurements can obtain values of the field elements to a precision of one part in 300 and can provide data in remote oceanic areas. The main disadvantage of such surveys, however, is that much time is needed to produce a magnetic grid of the vast oceanic regions. Moreover, at present there is only one non-magnetic ship, the *Zarya,* instrumented for vector measurements of the magnetic field. Many oceanographic research ships use a magnetometer mounted in a "fish," which is towed by cable far enough behind the ship so that the magnetic field of the ship does not influence the instruments. However, only the total-field strength, F, is generally obtained in this way. Vector magnetometers exist that could, theoretically, also be mounted in a fish, but it would not be possible either to maintain or to determine the orientation of the fish with sufficient accuracy to permit measurement of H and D. Even so, such

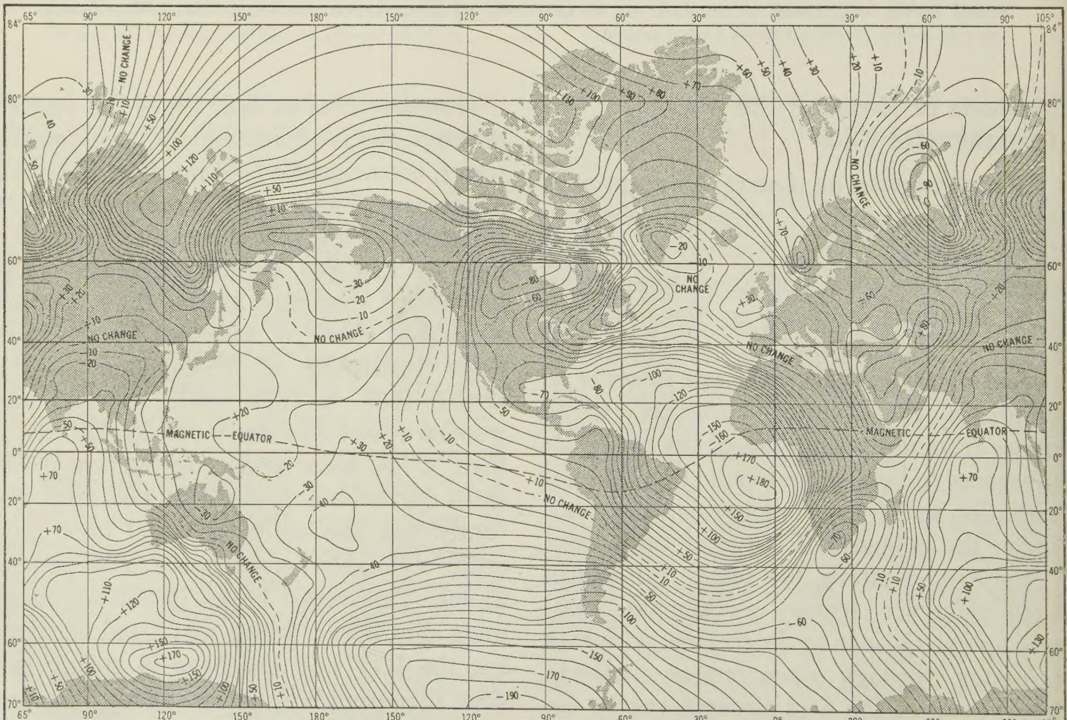

Fig. 5. *World Map of Secular Variation in Vertical Intensity, 1889–1955. Lines connect points of equal annual change, expressed in gammas (oersted value times 10^{-5}). Courtesy of* Encyclopaedia Britannica. (*Map based on US Navy Hydrographic Office chart.*)

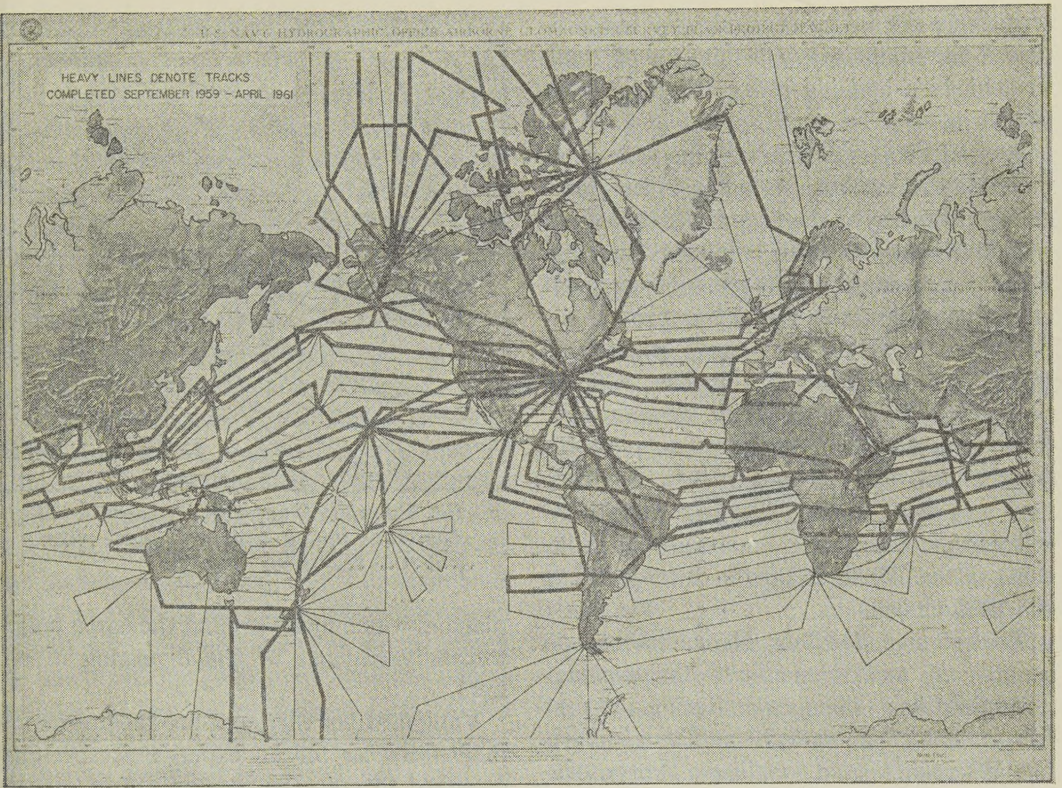

Fig. 6. *Flight Lines of Project Magnet of US Navy Hydrographic Office. USNHO chart.*

measurements of F alone can be used to help fill in gaps in magnetic coverage.

Airborne Measurements: It is now possible to survey the geomagnetic field with aircraft, using recently developed total-field magnetometers such as the flux-gate or proton-precession instruments. Measurements obtained by airborne techniques have proved most useful in geophysical exploration for mineral deposits and in studies of the structure of the earth's crust. The detail obtained, however, is too fine for mapping purposes as the flights are made at low altitudes and attention is concentrated on local anomalies. It has also proved possible to install vector magnetometers in aircraft for determinations of F, D, and I.

Canadian scientists have surveyed much of Canada from the air and have made some crossings of the Atlantic and Pacific Oceans. A major program of airborne survey—Project Magnet—in which two aircraft (a DC-4 and a Super-Constellation) have been fitted with extensive navigation equipment and vector magnetomers, is now being carried out by the US Navy Hydrographic Office. In this program, the true heading and magnetic heading are determined, permitting calculation of D, and I and F are also measured; thus, a complete description of the field is obtained. Figure 6 shows Project Magnet flight lines, both planned and already flown. A more-or-less regular grid pattern with 300-km (200-mi) spacing will be obtained over the ocean areas. Instruments are checked wherever possible against standard instruments at land observatories. It is calculated that under good conditions the total intensity is measured with a precision of $\pm$ 15 gammas and angular directions are obtained to within $\pm$ 0.1° of arc. Flights are made at altitudes ranging from about 1500 to 6000 meters, with most at about 3000 m; and ob-

servations are taken continuously but tabulated for about every 5 minutes of track to achieve a spacing along the flight path of 25 km.

Several Project Magnet flights were completed in the Antarctic (see Fig. 7) before an accident destroyed the Super-Constellation; a similar aircraft is now being modified and fitted out to carry on the work of the project. Meanwhile, the DC-4 has proved capable of providing long-range flights, six flights around the world having already been made with this aircraft. Some earlier data from Project Magnet were available for the 1960 D chart and data being taken now and for the next few years will constitute one of the most important contributions to the World Magnetic Survey and to the 1965 charts.

Rocket and Satellite Measurements: A number of measurements of the geomagnetic field have been made during the past few years by instrumentation flown in various US rockets and satellites. Proton-precession magnetometers have been carried aboard rockets to explore atmospheric electric currents arising from some solar disturbances and to study the diurnal solar-ionization and tidal forces near the equator.

A magnetometer carried by space probe Pioneer I explored the geomagnetic field to distances of about 115,000 km (70,000 mi). Results indicated that the field intensity decreased with distance from the earth according to an inverse-cube relationship between 3.7 and about 7 earth radii from the center of the earth, with large-scale fluctuations beyond. (The average radius of the earth is about 6370 km, or 3960 mi.) The data also indicated a transition between the geomagnetic and the interplanetary field at about 13.6 earth radii. From data of Explorer VI, which also carried a magnetometer, it was found that the field decreased as expected to about 5 earth radii, with regular large-scale deviations beyond, at least to 8 earth radii. It was deduced that the cause of the deviations is a ring current arising from trapped low-energy

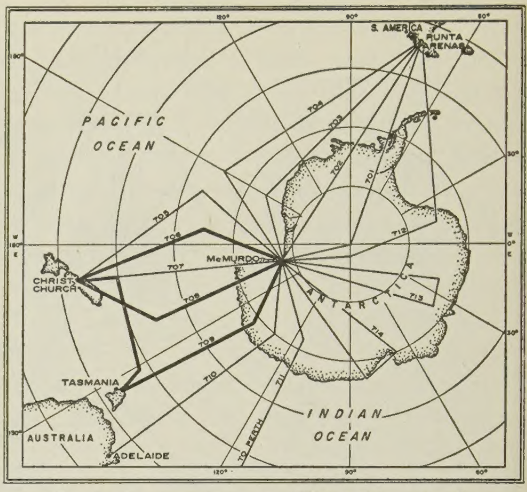

Fig. 7. *Project Magnet Flight Lines in the Antarctic. Heavy lines are flights completed as of October 1960.*

plasma, which drifts around the earth longitudinally because of the diverging dipole field.

Vanguard III carried a proton-precession magnetometer for an experiment specially designed to map the magnetic field at satellite altitudes (see *Bulletin No. 28*). Proton-precession magnetometers were also installed at telemetry stations for simultaneous ground-control observations during satellite passes. NASA scientists who analyzed the Vanguard III data have concluded that a simply instrumented satellite can give valuable information on the distant field and permit considerable refinement of the mathematical representations of the real geomagnetic field. (Details of Vanguard III results can be found in *Bulletin No. 46*). It is apparent from Figure 8, which shows some of the coverage obtained thus far by rocket and satellite magnetic observations, that there are still great gaps for which data are lacking; it is hoped that these gaps will be reduced by future satellite experiments.

General Plans for the WMS

International: Prior to the IGY the International Association of Geomagnetism and Aeronomy (IAGA) of the International

Union of Geodesy and Geophysics (IUGG) appointed a Special Committee on the World Magnetic Survey and Magnetic Charts, with E. H. Vestine as Chairman, to study the technical requirements for the World Magnetic Survey. Meetings were held during the XIth and XIIth IUGG General Assemblies at Toronto (1957) and at Helsinki (1960). The Committee has circulated recommendations regarding precision and spacing of measurements as well as possible satellite observations.

The International Geophysics Committee (CIG) of the International Council of Scientific Unions (ICSU, parent organization for international scientific unions) was assigned responsibility for international coordination of the WMS. The CIG requested ICSU's Committee on Space Research (COSPAR) to study possible contributions to the WMS by rocket and satellite observations. At the last meeting of COSPAR in Florence, Italy, April 1961, it was suggested that two satellites equipped with magnetometers be launched into polar orbits—one at a height of several hundred kilometers and the other at a distance of about 10 earth radii.

The international recommendations stemming from these meetings are now being considered by many countries as they plan their contributions to the WMS. A manual on observations and data analysis is also being prepared by the IAGA Committee for the use of scientists interested in participating in WMS.

United States: A Panel on the WMS, chaired by E. H. Vestine, was organized by the Geophysics Research Board of the National Academy of Sciences (discussed in *Bulletin No. 48*). Subsequent to the first meeting of the Panel, A. J. Zmuda, Applied Physics Laboratory of the Johns Hopkins University and J. F. McClay, Air Force Cambridge Research Laboratories, have joined the membership.

At its initial meeting, the Panel discussed the international recommendations and reviewed the expected United States contributions. Project Magnet, described above,

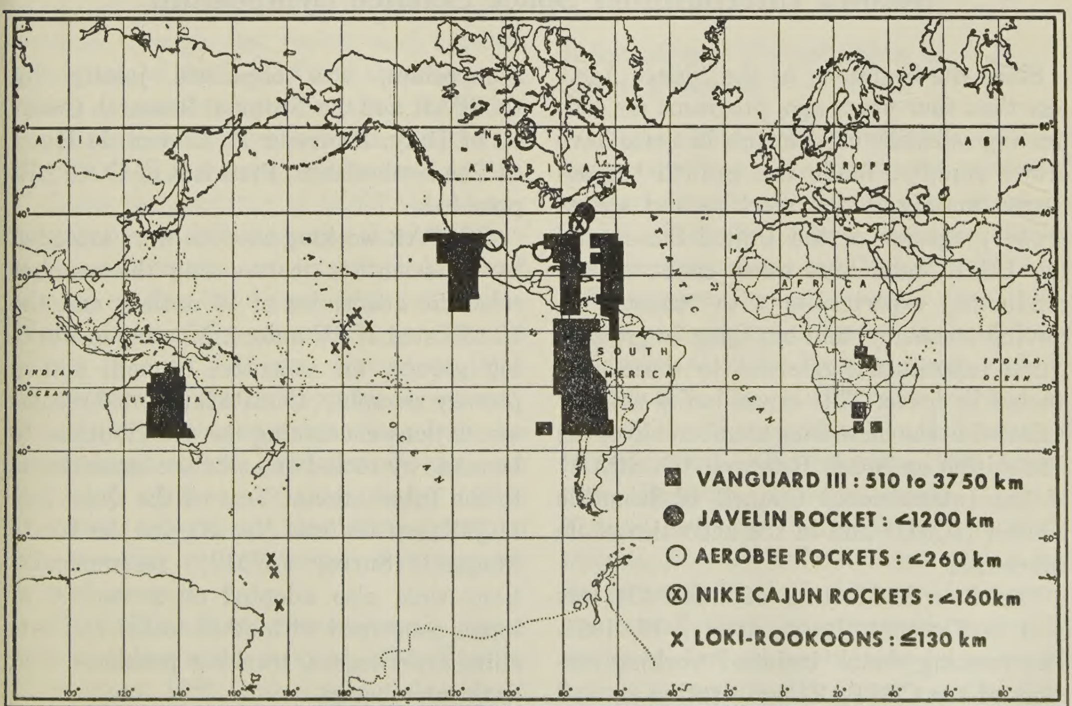

Fig. 8. *Areas of Magnetic Observations by Rockets and Satellites through 1960.*

will constitute one of the major US observational programs. In addition, the US Coast and Geodetic Survey plans to make observations at a network of field locations as well as to continue its normal observation program at the permanent observatories. Absolute measurements are also being made by Coast and Geodetic Survey personnel in Antarctica, both at the permanent stations and, with portable equipment, on over-snow traverses that are part of the glaciological research program.

The Panel has discussed the important contributions that satellite observations could make to the WMS and has adopted a recommendation that plans for the space-research program for this period include a satellite instrumented for magnetic-field measurements.

In the words of E. H. Vestine, Chairman of both the IAGA committee and the GRB Panel on the WMS, "The World Magnetic Survey is not a routine repeat of past survey activities. With the techniques available now, and with the spirit of international cooperation stemming from the IGY, it will be a first-class scientific experiment and will shed much light on understanding the geomagnetic field and its complex interrelationships with electrical phenomena in the upper atmosphere and with the solar-terrestrial environment."

International Activities in Space Science

Fourth Meeting of COSPAR and Second International Space Science Symposium

Since the beginning of the "Space Age," less than four years ago, programs for conducting scientific experiments in space have grown rapidly. While this growth has occurred mainly in the satellite and space-probe programs of the United States and the USSR, numerous other countries are conducting experiments with rockets, receiving telemetry, and engaging in ground-based experiments relevant to those conducted in space. This expansion is notably reflected in the increasing membership of the Committee on Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) and in the activities of its adherents.

The Fourth Meeting of COSPAR was held in Florence, Italy, April 7–18, 1961. The meeting, which included working sessions of the COSPAR organization as well as the Second International Space Science Symposium, was organized jointly by COSPAR and the National Research Council of Italy. Professor H. C. van de Hulst of The Netherlands, President of COSPAR, presided.

COSPAR working sessions were attended by 50 scientists representing the member scientific academies of 18 nations and the 10 affiliated ICSU unions. Meeting in working groups, an executive council, and a plenary assembly, COSPAR adopted recommendations concerning the contributions to be made by rocket and satellite experiments to the International Year of the Quiet Sun (IQSY; see *Bulletin No. 48*) and the World Magnetic Survey (WMS); recommendations were also adopted on a variety of topics concerned with other rocket and satellite experiments, tracking problems, and data interchange.

The number of participants in COSPAR's

Second Space Science Symposium exceeded 300, representing 27 countries and including some 65 from the United States. A total of 117 scientific papers were presented by scientists from 14 countries. The papers will be published shortly by the North-Holland Publishing Company. The scientific sessions covered radio and optical tracking, telemetry and data recovery, geomagnetism, research by use of rockets, reference atmospheres, the geophysical events of July 1959 and November 1960, and recent results from instrumented satellites and spacecraft.

History of COSPAR

COSPAR was established by ICSU in October 1958 as an outgrowth of the rocket and satellite programs of the International Geophysical Year. In its first three meetings, COSPAR developed a charter and organization, and initiated effective programs of international scientific cooperation. Information and results have been exchanged annually on the rocket and satellite programs of scientific institutions of member nations through the rocket and satellite subcenters of the IGY World Data Centers, which are continuing to function under arrangements similar to those employed during the IGY but somewhat more complete.

Under the guidance of COSPAR, an annual series of International Rocket Intervals has been successfully established, and special studies have been initiated—notably, a study of the remarkable geophysical events of July 1959 and November 1960. In addition, reference tables for the properties of the upper atmosphere have been developed and will be published shortly, and the needs of space experiments for radio-frequency allocations have been drawn to the attention of appropriate inter-governmental agencies.

COSPAR's First International Space Science Symposium, held at Nice, France, in January 1960, was attended by about 300 scientists and included 98 papers by participants from 12 countries. It resulted in publication of a valuable volume containing an extensive compilation of scientific results from experiments aboard rockets and satellites.

US Cooperative Programs: COSPAR has provided a climate for international cooperation in other ways. Through COSPAR, an offer was made on behalf of the US National Aeronautics and Space Administration to launch experiments of scientists from other countries. As a result of this offer, the first of three satellites instrumented by the United Kingdom will be launched in 1962. Canadian scientists are preparing an ionospheric-sounder satellite, also to be launched in 1962. With NASA cooperation, Italy has undertaken rocket launchings from Sardinia for sodium-vapor studies of the high atmosphere. Similarly, NASA and Australia are considering a joint program to launch rockets from Woomera, Australia, to map ultraviolet radiation in the southern skies. Similar joint projects are under discussion with other countries.

International Participation in Space Research

Since COSPAR was established there has been a significant increase in the number of nations capable of engaging in space research. Initially, seven member nations launched rockets or satellites as part of the IGY program. In addition to the United States and the Soviet Union, these included Australia, Canada, France, Japan, and the United Kingdom. Membership has now increased to 18 countries, the following 11 having joined COSPAR since 1958: Argentina, Belgium, Czechoslovakia, German Federal Republic, India, Italy, The Netherlands, Norway, Poland, South Africa, and Switzerland. Not all of these 11 countries are actually launching research rockets or satellites, but all participate in space research through tracking and receipt of telemetry from space vehicles, and through

ground-based studies and experiments of direct relevance to those conducted in space.

Canada and the United Kingdom, with the cooperation of the United States, may soon be added to the countries that have launched instrumented satellites, and still other countries should follow in the near future. Italy and Israel are new additions to the countries that have launched research rockets, and five or six other countries may be added to this list in the next few years.

The number of scientific communities with access to the technology required to launch scientific instruments into space should continue to increase. Moreover, the opportunities for scientists everywhere on earth to engage in space research are even now more numerous than appears on the surface—even for scientists without access to rocket technology. Investigations under way for many years at earth-based stations have been intensified and expanded as a result of the IGY and the advent of the space age. Much necessary work can be done by increasing balloon research to augment studies at higher altitudes with rockets and satellites.

Small rockets should soon become standard tools for meteorological observations in many parts of the world, and rockets for scientific measurements in other fields will continue to acquire critical information at sub-satellite altitudes for many years. Moreover, data telemetered by many satellites and space probes can be acquired either directly or indirectly by scientists everywhere. Once acquired, these data can be reduced, analyzed, and interpreted by these scientists just as if the experiment aboard the satellite were their own.

Finally, creative ideas for new satellite experiments, conceived and developed by scientists anywhere, have good prospects of realization in the space program of the United States through arrangements similar to those with the United Kingdom and Canada.

The growth in the number of nations engaging in space research in itself corresponds with one of the main objectives of COSPAR's charter. At the same time, this growth increases the opportunities for synoptic, or world-wide, observations and experiments that represent the primary function that COSPAR has inherited from the IGY.

Accomplishments of Fourth Meeting of COSPAR

At the Florence meeting, COSPAR took the first step in organizing a post-IGY cooperative scientific program with world-wide objectives. COSPAR's efforts will be directed toward developing specific contributions by experiments aboard rockets and satellites to important international scientific programs initiated and sponsored by other organizations in the ICSU complex. Two such programs—the IQSY and the WMS—have been organized by the ICSU International Committee on Geophysics (CIG).

The IQSY will undertake, based on knowledge obtained during the IGY period of maximum solar activity, measurements and observations of solar-terrestrial relationships during the coming period of minimum solar activity, in 1964 and 1965. A comparison of the measurements taken during the IGY and the IQSY should prove of immeasurable value to science.

The WMS will attempt to add to the world-wide network of ground-based magnetic observations, for the purpose of developing a new map of the earth's magnetic field, rocket-and-satellite measurements of the magnetic field in space. The WMS will be conducted on an international basis during the same period as the IQSY.

COSPAR's Working Group II, on "Scientific Experiments," adopted 11 general resolutions defining the basic scientific objectives of the IQSY and WMS programs toward which rocket and satellite contributions should be made. Subsequent meetings of experts in specific scientific disciplines will

be held to refine these general resolutions through preparation of specific international program recommendations concerning experiments that depend on world-wide coverage, synoptic observations, or both. The first of these meetings will take place at Kyoto, Japan, in September 1961 as an adjunct to the International Conference on Cosmic Rays and Earth Storms, which is being convened under the auspices of the International Union on Pure and Applied Physics.

The Kyoto conference provides an opportunity to assemble scientists in the fields of cosmic rays, energetic solar particles, and geomagnetism from a large number of countries in order to define the specific projects and detailed modes of cooperation required to provide for the fullest elaboration of both the IQSY and the WMS. For example, the possibility exists of using a coordinated pair of satellites for the WMS. These satellites would differ in altitude and orbital characteristics, but would make correlative measurements of the earth's magnetic field.

Other current activities of COSPAR working groups include development of a comprehensive world list of tracking stations for the use of satellite experimenters, further refinement of the world-wide system for rapid communication of satellite and space probe information, and improvements in the arrangements for exchange of scientific results of rocket, satellite, and space-probe research.

Plans for Future Meetings

Further refinement of several aspects of the COSPAR program will be carried out in a series of international meetings and symposia on special space problems; these meetings are being arranged under the auspices of COSPAR for the coming year, in many cases in cooperation with other organizations within the ICSU family. An informal meeting on basic biological problems of space exploration, including exobiology and avoiding contamination of the Moon and planets by vehicles landing on their surfaces, was planned in conjunction with the meeting of the International Union of Biochemistry, in Moscow, August 1961. Also, a special meeting on tracking-accuracy requirements for space research in the Southern Hemisphere was convened as an adjunct to the meetings of the International Astronomical Union, in Berkeley, August 1961.

The National Academy of Sciences and its Space Science Board will act as host at the next General Assembly of COSPAR, to be held in Washington, D. C., April 30–May 11, 1962. This meeting will also include the Third International Space Science Symposium, and two symposia on special topics are being organized in cooperation with other international organizations.

A symposium on the Geodetic Uses of Satellites, planned by the International Association of Geodesy and COSPAR, will probably take place in Washington the week prior to the COSPAR meeting. The second symposium on the Meteorological Uses of Rockets and Satellites will also be convened in Washington, jointly by COSPAR, the World Meteorological Organization, and the International Union of Geodesy and Geophysics, in conjunction with the 1962 COSPAR meeting.

Conclusion

COSPAR is facilitating the expansion of the world's space research by encouraging and assisting new scientific groups to undertake the scientific tasks of space research and by harmonizing the programs based on these separate efforts. COSPAR also provides a suitable environment for discussion and exchange of ideas by space scientists, for indicating technical needs, and for establishing internationally endorsed scientific objectives. Cooperation between groups of scientists working in different countries is thus facilitated because the efforts of each group constitute contributions to scientific programs discussed and developed on an international basis.

Full realization of the scientific possibilities opened up by access to space calls for extraordinary efforts. Some of these efforts will be beyond the resources of any one nation, and the success of many of them, because of their global or cosmic scope, will depend upon the cooperation of a number of nations. The success of all of them would be greatly enhanced if carried out cooperatively.

Tiros III Weather Observation Satellite

Since its successful launch on July 12, 1961, Tiros III (1961 Rho), the third in the Tiros series of television and infrared observation satellites, has transmitted back to earth thousands of cloud-cover photographs, including many high-quality pictures of hurricanes and other large tropical storms. (See Figures 9, 10, and 11.) As the projected experimental lifetime of Tiros III corresponds largely to the current hurricane season, the satellite is thus fulfilling the hopes of meteorologists that it would provide valuable insights concerning the origin, development, and movement patterns of these great storms. Tiros III is also providing weather forecasters with immediately usable information on the location and growth of such storms, as well as on other weather conditions, in oceanic areas for which little or no weather data are otherwise available.

Launched by a 92-foot, 112,000-pound Delta vehicle at 6:25 am EDT, July 12, from Cape Canaveral, Florida, Tiros III entered an almost circular orbit at an average altitude of approximately 485 statute miles. About a month after launch, the satellite's orbital elements were as follows: perigee, 457.4 statute miles; apogee, 509.4 statute miles; inclination, 47.9°; and period 100.4 minutes.

Payload Details and Instrumentation

Tiros III closely resembles its predecessors, Tiros I and Tiros II (described, respectively, in *Bulletin Nos. 35 and 43*), in shape, weight, and dimensions. The 285-pound cylindrical satellite is 42 inches in

Fig. 9. *Tiros III Photograph of Tropical Storm Liza, West of Baja California, July 19, 1961. Storm was in an area from which no weather reports are available; its position could be estimated only after Tiros pictures made it possible to locate storm center—at about 25° N, 121° W.*

diameter and 19 inches high. Its outer surface is covered with 9260 solar cells to provide electrical energy for the 63 nickel-cadmium storage batteries that power its electronic instrumentation.

Unlike Tiros I and II, each of which carried one wide-angle and one narrow-angle vidicon television camera to provide both low- and high-resolution photographs, Tiros III was equipped with two wide-angle cameras. Experience with the first two Tiros satellites showed that wide-angle pictures were of greater value for weather interpretation. The narrow-angle pictures were found to be useful essentially for research, and a sufficient number of them has already been obtained for this purpose from Tiros I and II. Moreover, Tiros II was still transmitting narrow-angle photographs at the time Tiros III was launched.

One of Tiros III's television cameras failed on July 24, following the satellite's 170th orbit and after taking 2020 high-quality cloud-cover photographs. The other camera was then put into full-time use. The possibility of failure of a camera was one of the reasons for using two identical cameras.

As did the first two Tiros', Tiros III contains magnetic tape recorders that can store up to 32 pictures per orbit for transmission to the earth when the satellite comes within the 1500-mile command range of a ground station. The satellite also carries improved remote-control programmers for the electronic equipment and new transistorized circuits in the electronic clocks that trigger the cameras. Other instrumentation in the latest Tiros satellite, including beacon transmitters, attitude sensors, horizon scanners, telemetry circuits, and a magnetic orientation control system, is identical to that used in Tiros II (see *Bulletin No. 43*).

Tiros III also carries one scanning and one non-scanning radiation experiment that are essentially the same as those carried in Tiros II, plus one additional non-scanning experiment. The scanning experiment, consisting of five sensors to map radiation in various spectral ranges, is designed to provide information on reflected solar radiation, on long-wave radiation emitted from the earth and the atmosphere, on temperatures of the earth's surface or of cloud tops, and on the upper margin of water vapor in the atmosphere.

The first non-scanning experiment is intended to provide gross heat-budget information for the portions of the earth's surface and atmosphere viewed by the television cameras. The new non-scanning experiment is similar to one used successfully in the Explorer VII satellite (see *Bulletin No. 29*) and also measures the gross heat budget; however, the data will be nearly continuous as the sensors view the earth almost all of the time.

Data from the radiation experiments are recorded continuously on magnetic tape through one orbit and are played back on command from one of the ground stations. If not played back during an orbit, the tape is automatically erased as it accumulates new data from the next orbit.

Ground-Command Stations

The two primary NASA stations for command and data read-out in the Tiros III experiment are at Wallops Island, Virginia, and the Pacific Missile Range, California. Stations located at the Atlantic Missile Range, Florida, and at RCA's facility in Princeton, New Jersey, serve as back-up.

International Cooperation

Immediately after successful orbit of Tiros III was verified, notification was sent to COSPAR, in The Hague, along with initial orbital data and a description of the satellite and its instrumentation. In addition, NASA and the US Weather Bureau have invited other countries to participate in the experiment in order to provide them with the opportunity to correlate their own

Fig. 10. *Tiros III Photograph of Hurricane Anna, July 20, 1961, at 13° N, 65.5° W. Cloud-covered Leeward and Windward Islands, in the West Indies, appear as line of bright spots transverse to main spiral cloud band.*

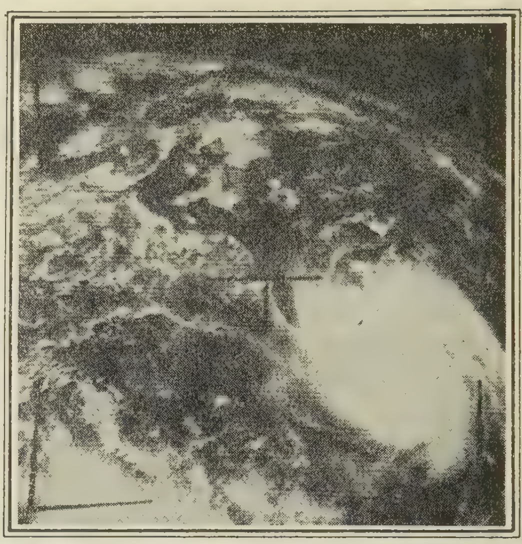

Fig. 11. *Hurricane Anna, July 21, 1961, about 25 Hours After Picture Shown in Figure 10 was Obtained. Hurricane's center had moved to about 14° N, 72° W, some 450 miles to the west. Coast of Colombia near Barranquilla is near center of photograph; Lake Maracaibo, Venezuela, is prominent dark area below center.*

ground-based observations with Tiros III cloud-cover photographs.

International Meteorological Satellite Workshop: The US Weather Bureau and National Aeronautics and Space Administration will hold an International Meteorological Satellite Workshop in Washington, D. C., November 13–22, 1961. More than 100 nations of the world have been invited to send one or two meteorologists each.

Through a series of lectures and laboratory-type meetings in which they will use Tiros photographs to prepare weather analyses, the participants will gain practical experience in the use of the satellite meteorological data distributed by the United States through international meteorological channels. Short lectures will also cover engineering aspects of the Tiros satellite system, the data acquisition system, significant results thus far, and program plans for future meteorological satellite systems. If a weather satellite is functioning during the period of the workshop, participants will be shown the principal ground elements of the system in actual operation.

While the Tiros program has demonstrated the great potential of weather satellites as important sources of forecast information for weather services, the introduction of this new type of data into daily weather analyses has presented problems that are as yet only partly solved. Discussions among meteorologists of the world may provide some answers.

Preliminary Results

Tiros III has transmitted photographs of a large number of tropical storms around the globe in a 6600-mile-wide band between approximately 48° N and 48° S during the past summer. Among these were some in oceanic areas where regular weather observation facilities are lacking. Figures 9, 10, and 11 are Tiros III pictures of three of these storms taken during the satellite's first few weeks in orbit.

Among the storms for which no previous

information was received from regular sources were two, still in the infant stage, photographed about 500 miles south and southeast of Hawaii on August 17. In addition, cloud pictures made available to Japan in the early summer proved to be of very considerable aid in weather prediction, and it was hoped that Tiros III's passes near Japan from about August 18 to September 25, a period during which typhoon activity was expected to be high, would also provide vital assistance to forecasters.

Energetic Cosmic-Ray Air Shower

An extremely large cosmic-ray air shower, triggered by a primary cosmic-ray particle that probably originated outside our galaxy, has been observed at the Volcano Ranch cosmic-ray station of the Massachusetts Institute of Technology. The station, at an elevation of 5800 feet near Albuquerque, New Mexico, employed an array of scintillation counters designed to detect and measure such showers. The event is described in a report by John Linsley, Livio Scarsi, and Bruno Rossi, in *Physical Review Letters,* May 1, 1961.

Primary cosmic rays entering the earth's atmosphere collide with nuclei of atmospheric atoms. These collisions produce secondary cosmic-ray particles, which, in turn, strike still other air particles, producing tertiaries, and so forth. Thus, the entry of high-velocity cosmic rays into the earth's atmosphere may result in showers at the earth's surface consisting of hundreds of millions, or billions, of particles.

The core of the shower described struck the earth's surface several hundred meters south of the boundary of the array of 19 detectors, which occupied an area of approximately two km^2. On the basis of the particle densities observed at the various detectors, it was calculated that the total number of particles in the shower was at least 5.5 billion, and may have been 4 to 8 times that many.

A cosmic-ray air shower of this size could be precipitated only by a primary particle having an energy of 10^{19} electron volts or greater. In a magnetic field of 3×10^{-6} gauss, the commonly estimated intensity of the galactic magnetic field, a proton of this energy would have a radius of curvature of about 10^4 light years. However, the radius of our galaxy is only about 5 times this value while its thickness is approximately 5 or 10 times smaller. Thus, it appears certain that the primary particle causing this shower must have acquired its energy outside our galaxy. Cosmic-ray primaries originating within our galaxy could have energies up to about 10^{19} ev, but not greater.

Analysis of the distributions of arrival times and particle densities at the various detectors indicates that the extreme front of the shower was well-defined, and that, while many particles were delayed by as much as 1 or 2 microseconds, few of them were delayed by more than twice the mean delay time. It appears that these general features of distribution also characterize smaller showers. It also appears that the radius of curvature of the front of this shower was about 10 to 12 kilometers, i.e., an appreciable fraction of the air-shower particles began to diverge strongly from the shower axis in this height range. The results further suggest that for shower par-

ticles arriving at distances greater than 1500 meters from the shower axis, at an elevation of 5800 feet, this divergence from the axis occurs at heights greater than 7 km above the ground.

Since the Volcano Ranch Station went into operation, in September 1959, only two such high-energy cosmic ray events, apparently involving extra-galactic particles, have been detected.

West Ford Review

(A Review of Space Science Board Activities and the United States Government Policy Position)

A report in the August 1961 IGY Bulletin *described the design and purpose of the Project West Ford communications experiment and discussed its possible relationships to other branches of science. The following is a summary report distributed by the National Academy of Science's Space Science Board to the scientific public and the press concerning the Board's activities and findings regarding Project West Ford and including the full text of the policy position announced by the United States Government on August 11, 1961, concerning the experiment.*

A Summary Report on Project West Ford

Project West Ford is a proposed program of the United States Government to investigate experimentally a new system of long range communications. Because the experiment proposes to place a narrow belt of minute microwave reflectors in a high altitude orbit, astronomers have been interested in the experiment, many expressing concern that interference to basic astronomical measurements might ensue.

The Space Science Board of the National Academy of Sciences, which has closely followed development of this project since its inception, considers it useful to recapitulate the plans for this experiment and to place in proper perspective its views regarding the interests of basic science. For this purpose there follow:

I. A résumé of Space Science Board activities and findings regarding Project West Ford

II. A statement of the policy position of the United States Government regarding the project

III. The Board's views on the question of possible effects on astronomical research.

I.

In the fall of 1959 the Space Science Board was informed of the proposal by the Massachusetts Institute of Technology Lincoln Laboratory to erect a belt of thin microwave dipoles in a polar orbit about the Earth at an altitude of a few thousand kilometers to obtain experimental verification of such a system for reliable long range radio communications. This experiment involves the establishment of a belt consisting of some 35 kilograms of dipoles, resonant at about 8000 megacycles and therefore serving to reflect radio waves at this frequency.

Each dipole is 1.77 centimeters long with a diameter of 0.00286 centimeters. 3.5×10^8 dipoles are involved, distributed uniformly along the orbit and subsequently dispersing until, at 60 days after launch, a belt 8 kilometers wide by 40 kilometers thick is formed. At this time the density will be about 21 dipoles per km^3. The orbital altitude for the experiment has been chosen to ensure that solar radiation pressure effects will act to produce an ever increasing eccentricity in the orbit, thus bringing perigee into the atmosphere within a few years with consequent belt destruction.

Extensive theoretical and laboratory studies of the properties of orbiting dipole belts have been carried out by Lincoln Laboratory. In addition, at the request of the Director of Lincoln Laboratory, the Space Science Board undertook to examine the effects of the proposed experiment to ascertain whether the project would have any noticeable effects on activity in any field of research.

The Board, on December 24, 1959, appointed an ad hoc committee of scientists under the chairmanship of Dr. O. G. Villard, Jr. (Stanford University) to examine the consequences of the proposed experiment. Astronomers on this committee included G. M. Clemence (U. S. Naval Observatory), C. H. Mayer (Naval Research Laboratory), and F. L. Whipple (Smithsonian Astrophysical Observatory). The committee held several meetings during the first half of 1960 and invoked the assistance of some 20 additional scientists including optical and radio astronomers and other specialists.

Acting upon the findings of this committee, the Space Science Board in June 1960 reached a number of conclusions and adopted several recommendations: (i) This exploratory test would not have an adverse effect on any branch of science. (ii) There is justifiable concern for the interference which an operational system might entail for optical and radio astronomical observations: any planning for such a system must protect the interests of astronomical research and of science in general. (iii) Full information on the scientific and operational aspects of the initial experiment should be published as soon as possible. (iv) In view of the possible interference to radio astronomy, which might result not only from extensive dipole belts but also from active and even passive communication satellites, frequency bands for radio astronomy should be provided on the basis of world-wide agreements.

The Board also decided that continued study of the subject was worthwhile, and in this the Lincoln Laboratory concurred. Accordingly, the Board established a special committee on July 29, 1960. The present composition of this committee is as follows: John Findlay (National Radio Astronomy Observatory) (Chairman), F. T. Haddock (University of Michigan), William Liller (Harvard University), A. E. Lilley (Harvard University), W. A. Hiltner (Yerkes Observatory), and Allan Sandage (Mount Wilson and Palomar Observatories). Leo Goldberg (Harvard University), chairman of the Board's astronomy committee, meets with the group. The committee was asked by the Board to examine carefully all calculations of the effects of the West Ford experiment on astronomy, to recommend additional necessary research or study, and to report its scientific findings to the Board. The committee has maintained continuous liaison with the project throughout the past year and has formally convened with West Ford project directors of Lincoln Laboratory on three occasions. At each of these sessions the committee has received a thorough review of the project status and full information on all parameters of the experiment.

The Space Science Board has felt that a discussion of the proposed experiment should not be limited to committee consideration, but should be brought out for critical analysis by the scientific community as a whole. Accordingly, as a result of the foregoing recommendation (iii) of the Space Science

Board and following almost immediately the initial discussions of its committee with Lincoln Laboratory scientists (29 August 1960), the Laboratory concurred with the request for presentation of their work on orbiting dipole belt properties to the international scientific community. Dr. W. E. Morrow, Lincoln Laboratory Project West Ford Director, presented a paper on the topic before the general assembly of the International Scientific Radio Union (URSI) in London in September 1960.

The Board has also recommended that the theoretical and technical aspects of the West Ford project should be published in the astronomical literature so that astronomers throughout the world could examine for themselves the calculations on which the project is based. For this purpose, four articles were published in the *Astronomical Journal*, Vol. 66, No. 3, pp. 105–118, April 1961. Some 1400 copies of these papers have been distributed by the Board to the scientific community, over 1100 of them to members of the International Astronomical Union, including 800 astronomers abroad.

During the course of its considerations the Committee also established the desirability of securing the widest possible participation of observational astronomers to study the characteristics of the Project West Ford belt to determine its performance under actual conditions. In March, 1961, the committee distributed a circular letter to a large number of optical astronomers throughout the world (i) providing a technical description of the experiment, (ii) containing recommendations for an observational program which might be undertaken, and (iii) inviting the cooperation of individual astronomers in obtaining observations and measurements.

II.

The Space Science Board's recommendations on Project West Ford have been made available to the government as they were developed. In response to these recommendations, made by the Board on behalf of the scientific community, the government has issued appropriate policies. These, as transmitted by the Special Assistant to the President for Science and Technology to the Chairman of the Space Science Board, follow in full:

THE WHITE HOUSE
Washington

August 11, 1961

Dear Dr. Berkner:

I would like to acknowledge the recommendations and assistance of the Academy's Space Science Board in its studies of the proposed West Ford experiment. In particular, I should like to note with appreciation the consideration given to this topic, at my request, during the last few months as to the effects of the experiment and possible other experiments from the standpoint of science as a whole.

As a result of these technical studies, a statement of policy was prepared by the National Aeronautics and Space Council—a body whose Chairman is the Vice-President of the United States and whose members include the Secretary of State, the Secretary of Defense, the Administrator of the National Aeronautics and Space Administration, and the Chairman of the Atomic Energy Commission. This statement, which I believe expresses the interest of all parts of the Government in continued development of basic science, has been approved by the President.

I would be pleased if you would disseminate the statement, a copy of which is enclosed, to members of the scientific community.

Sincerely yours,
Jerome B. Wiesner

Project West Ford: U. S. Policy

"Project West Ford is a communications experiment designed to place about 75 pounds of hair-like filaments (dipoles) into a short-lived belt around the earth. This project has been planned in such a way that no harmful effects can be expected. It is being performed for the United States Government by the Lincoln Laboratory of the Massachusetts Institute of Technology and is a single experiment for the purpose of:

"a. Investigating the technical feasibility of utilizing orbiting dipoles as passive reflectors for relaying communications; and

"b. Providing an opportunity for an objective assessment of the possible effects of the dipole technique on space activities or on any branch of science.

"The United States Government, in conducting the West Ford Project, will be guided as follows:

"1. No further launches of orbiting dipoles will be planned until after the results of the West Ford experiment have been analyzed and evaluated. The findings and conclusions of foreign and domestic scientists (including the liaison committee of astronomers established by the Space Science Board of the National Academy of Sciences) should be carefully considered in such analysis and evaluation.

"2. Any decision to place additional quantities of dipoles in orbit, subsequent to the West Ford experiment, will be contingent upon the results of the analysis and evaluation and the development of necessary safeguards against harmful interference with space activities or with any branch of science.

"3. Optical and radio-astronomers throughout the world should be invited to cooperate in the West Ford experiment to ascertain the effects of the experimental belt in both the optical and radio parts of the spectrum. To assist in such cooperation, they should be given appropriate information on a timely basis. Scientific data derived from the experiment should be made available to the public as promptly as feasible after the launching."

III.

In the light of its studies and of the above governmental policy, the Space Science Board concludes:

(1) The Project West Ford experiment will constitute no interference to optical or radio astronomy. As a matter of fact, the belt will be barely detectable, even by astronomers with advance information and upon the taking of special efforts for detection.

It is true that a belt or belts could be erected which could cause interference to astronomical observations; however, the United States Government policy provides (Section II, above) that no further launches of orbiting dipoles will be planned (i) until the West Ford results have been analyzed and evaluated and, further, (ii) will be contingent on the development of necessary safeguards.

(2) The Board will continue its studies of this area of experimentation on behalf of the scientific community. In these studies it will depend on objective and quantitative assessments that constitute the foundation for scientific discussions, recommendations and decisions. These assessments can only be achieved through a carefully controlled, harmless test, and Project West Ford provides a clear opportunity for scientists of all nations to cooperate in making observations to form the basis for an objective understanding of the behavior of an orbiting dipole belt, both in terms of its astronomical properties and of its communication capabilities.

(3) The Board will continue to keep the scientific community everywhere informed and it invites the cooperation and assistance of scientists everywhere who have interest and specialized knowledge in this area. The Board acknowledges with gratitude the assistance of many scientists—both at home and abroad—who have already contributed to its studies.

International Astronomical Union Resolutions

The Eleventh General Assembly of the International Astronomical Union, held in Berkeley, California, August 15–24, 1961, adopted two resolutions concerning the launching of space experiments that might affect astronomical research. The full text of these resolutions is as follows:

Resolution No. 1—Viewing with great concern the grave danger that some future space projects might seriously interfere with astronomical observations in the optical as well as in the radio domain,

and *believing* that a degree of contamination of space which at the present time would be hardly detectable, might, if long-lived, well be disastrous to future observations with improved techniques,

and *maintaining* that no group has the right to change the Earth's environment in any significant way without full international study and agreement;

the International Astronomical Union *gives* clear warning of the grave moral and material consequences which could stem from a disregard of the future of astronomical progress,

and *appeals* to all Governments concerned with launching space experiments which could possibly affect astronomical research to consult with the International Astronomical Union before undertaking such experiments and to refrain from launching until it is established beyond doubt that no damage will be done to astronomical research.

Resolution No. 2—The International Astronomical Union expresses its appreciation that the plans for Project West Ford have been publicly announced well ahead of proposed launching and of the United States Government's official policy* that further launchings will be guided by the principle that such projects shall not be undertaken unless sufficient safeguards have been obtained against harmful interference with astronomical observations.

Nevertheless the International Astronomical Union views with the utmost concern the possibility that the band of dipoles proposed in Project West Ford might be long-lived, and it is completely opposed to the experiment until the question of permanence is clearly settled in published scientific papers with adequate time being allowed for their study. The International Astronomical Union is opposed to any experiment which might hamper future developments in astronomy.

If a short lifetime for the dipoles and the harmless nature of the experiment can be assured, and if Project West Ford is carried out, the International Astronomical Union regards it as essential that the fullest observations of, and experiments on, the properties and behavior of the band of dipoles be carried out by all possible means. The observations and experiments should be performed and analyzed according to the highest scientific standards and with the best equipment available, bearing in mind that signals which are barely detectable today will probably cause serious interference with future scientific research because of the development of more sensitive equipment.

The observations and experiments to be made on West Ford are likely to be difficult to perform and will, in many ways, be similar to those carried out by the authorities responsible for operating West Ford. Moreover, much specific information such as precise and up-to-date ephemerides will be required. The International Astronomical Union will attempt to arrange for rapid and full cooperation among astronomers making observations and calculations, and to provide for world-wide dissemination of their results conforming to accepted standards of scientific research.

The International Astronomical Union welcomes the position* taken by the Government of the United States that any decision on later experiments of the West Ford type will be taken in the light of the results obtained from the presently proposed experiment. To enable the International Astronomical Union to obtain the necessary data, it requests the Government of the United States to grant full privileges to a group of astronomers, acceptable both to the Government and to the Union, to co-operate with West Ford authorities in performing quantitative experiments to determine the properties of the proposed belt of dipoles, its changes with time and location, and its impact upon present and future astronomical research.

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* Letter of August 11, 1961, from Dr. J. B. Wiesner to Dr. L. V. Berkner.

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